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An Experimental Study of Auctions Behavior With Risk Preferences

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ABSTRACT

There is an inherent risk in purchasing and selling an object at auction. Recent experimental studies demonstrate that risk preferences influence the bidding behavior of buyers, but they report varying results for the effects of risk attitudes on the expected revenues of different auctions. For example, literature reports that when bidders are risk-preferring, revenues in premium auctions are much greater than in a risk-averse setting, while reporting the opposite of that claim for the FPA. We conducted an experiment to investigate that claim about the hybrid Dutch auction (HDA), taking into account two distinct risk preference groups. Our findings indicate that, similar to the FPA, revenues in the HDA grow with risk aversion. Bidders with lower values bid more aggressively than bidders with higher values in both risk-averse and risk-loving treatments. The results also revealed that the amount and variance of shading increase significantly with value. Moreover, greater competition has a greater impact on the stability of the HDA with risk-seeking and risk-averse bidders than on the expected revenues. Finally, the study indicates that a small number of participants may be the reason why some experiments found that auctions generate less revenue than they would in a symmetric equilibrium and that participants rarely follow the equilibrium strategy.

1. Introduction

Since antiquity, auctions have been widely utilized as a valuable market mechanism. This selling mechanism has achieved a fundamental role in the global free market economy [1]. Auctions are significantly more important now than they were in the past. As they have been for millennia, commodities such as seafood, rough diamonds, and fresh flowers are sold at auction. Frequently, financial products, such as government bonds and assets, are offered using modernized adaptations of traditional auction formats. Governments have increasingly utilized auctions for the sale of rights to radio frequencies, petroleum, minerals, and timber, as well as for the acquisition of a vast array of commodities and services from private companies [2]. In recent years, online auctions have increased in popularity due to the demand for virtual sale options and technological accessibility [3]. eBay supports consumer-to-consumer, business-to-consumer, and business-to-business transactions through auctions. Yahoo! and Google sell advertisements and keyword positions through auctions [2].

Auctions could be conducted in a variety of formats. There are, however, two that are more prevalent than others: the ascending clock and the uniform-price sealed bid auction. Despite the common consensus that the uniform-price auction is more resistant to collusion, the ascending auction is deemed superior for information aggregation [4]. Furthermore, sealed-bid auctions are less likely to result in efficient outcomes than ascending auctions. Typically, the English auction is susceptible to collusion. It could also make weaker bidders (those with less knowledge or lower estimates) less likely to participate [5-6]. A solution to the difficulty of choosing between the sealed-bid (Dutch) and ascending (English) forms is to mix the two into a hybrid, the "Anglo-Dutch," which captures the best characteristics of both and was initially described and recommended in Klemperer (1998) [7]. In the Anglo-Dutch auction, the winners of the first stage, the English auction, receive a cash premium. The finalists continue to the second round, the Dutch auction [8].

The upgraded format of the Anglo-Dutch is labeled the Premium auction (PA) or Amsterdam auctions. The Amsterdam auction consists of two phases. In the initial phase, the price increases until all but two bidders have withdrawn. The level at which the final bidder departs the bidding process is known as the "bottom price," which serves as the reserve price for the second round. During this part, both finalists submit sealed offers; the highest bidder acquires the item; and both bidders earn some "payback", called a premium, equivalent to the difference between the lowest sealed bid and the minimum price

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[9]. In the "first-price Amsterdam auction", the winner pays her own bid, whereas in the "second-price Amsterdam auction," she pays the other finalist's bid [10].

Despite the many advantages of the PA, this format has poor performance in symmetric environments [10]. A hybrid Dutch auction (HDA) is a new format that simultaneously attracts more bidders, restricts collusion, facilitates price discovery, and generates high revenues in both symmetric and asymmetric environments. The HDA consists of the Dutch, sealed bid, and best bid stages. The "Dutch winner" is simply the first bidder who claims the lot at the accepted price at the auction's first stage; she does not participate in the second stage, which consists of privately submitted sealed bids. The highest bidder wins the second stage [6]. The "best bid" stage allows the Dutch winner to compete with the sealed bid winner for the lot. The item is awarded to the bidder whose bid is the highest overall [7, 11].

There is an inherent risk in purchasing and selling a property at auction. Bidders are apprehensive about their odds of winning and the amount they should pay, while sellers are uncertain about the likelihood of a successful sale and revenue [12]. A fundamental example of a force that extends beyond the standard model is risk aversion, which has been recognized as playing a significant role in economic decision-making across a variety of fields of choice [13]. Risk-averse bidders in auctions respond to the inherent uncertainty in the payment procedures and allocation, resulting in behavior that differs significantly from their risk-neutral opponents. This creates a more important role for the designers of the auctions, who may benefit from considering and possibly leveraging this risk-aversion [12]. Recent experimental investigations have examined standard auctions, the English PA (EPA), and the Anglo-Dutch in relation to risk preferences [12, 14-15]. The results of these experiments are partially compatible with theory and confirm the common belief that bidders' attitudes to risk are a significant element that influences bidding strategy and, subsequently, the seller's expected revenue [14]. However, the findings reveal that following the equilibrium strategy by subjects happens infrequently, especially in hybrid formats, so revenues in the experimental studies are typically lower than in symmetric equilibrium [12].

In this paper, we consider a classical symmetric and private value setting under the assumption that bidders display CARA. We use an experiment to study the HDA, accounting for different risk preferences for bidders. To guarantee that our experiment is more consistent with the model assumption of ex ante symmetric bidders, we separate potential subjects into risk-averse and risk-seeking groups as a novel component of our research. Using the method described by Holt and Laury (2002) [13], this is achieved. The filling out of the questionnaire by subjects takes place ten days before the main auction experiment. Then, each group is invited to separate HDA sessions for the main experiment.

We compare results obtained from the experiments of the HDA with the theoretical predictions of the EA and the EPA (expected revenues), considering different attitudes to the risk. No monetary incentives were used in the experiments. However, university participants were subject to grade incentives. Our findings indicate that, similar to the FPA, revenues in the HDA grow with risk aversion. Bidders with lower values bid more aggressively than bidders with higher values in both risk-averse and risk-loving treatments. The results also revealed that the amount and variance of shading grow significantly with value. Moreover, greater competition has a greater impact on the stability of the HDA with risk-seeking and risk-averse bidders than on the expected revenues. Finally, the study indicates that a small number of participants may be the reason why some experiments found that auctions generate less revenue than they would in a symmetric equilibrium and that participants rarely follow the equilibrium strategy.

The remainder of the report is structured as follows. Section 2 presents the literature review. The theoretical background is introduced in section 3. In Section 4, the experimental design is described. The results are presented and discussed in Section 5. In Section 6, we draw a conclusion and make recommendations for future research.

2. Literature review

While conventional auction analysis often assumes buyers have a neutral attitude to the risk, extensive evidence from real-world data and laboratory tests suggests bidding behaviors are frequently more compatible with a risk-averse bidder model. Risk aversion has several consequences for the design and comprehension of auctions. Vasserman & Watt (2021) studied the theoretical literature on how auctions should be structured under various conditions when bidders are risk-averse bidders [12]. Their study revealed that the mechanism of the auction influences the risk allocation among both parties (bidders and the seller) and the behavior of the bidders who are risk-averse. It results in a breakdown of the revenue equivalence theorem, increasing the importance of auction design decisions.

Several recent experimental works studied standard auctions, the EPA, and Anglo-Dutch in the context of risk preferences. In Table 1, we present crucial insights regarding the auction behavior of agents with varying risk preferences. In some theoretical and empirical literature, risk-seeking is referred to as gain-seeking, risk-preferring, and risk-loving too. Loss-averse is also used as the equivalent to risk aversion.

Key takeaways from the literature on standard auctions, the EPA, and Anglo-Dutch with risk preferences can be summarized as:

Different ways of valuation (dependent or affiliated) or modeling of the bidder's utility and reference point can lead to very different predictions.

The risk-averse seller prefers FPA to SPA and has lower reserve prices than the risk-neutral seller.

Optimal reserves are lower than the risk-neutral setting and lower in the FPA than in the SPA.

When bidders are risk-preferring, revenues in premium auctions are much greater than in a risk-averse setting. The opposite is true for the FPA.

When bidders are risk-averse, offering a premium lowers the expected revenue. When bidders are risk-seeking, it raises expected revenues.

When bidders are sufficiently risk-averse and the valuations are independent, no hybrid format can yield as much as an FPA. The opposite is true with regard to the English auction.

Table 1: main takeaways from the literature on standard auctions, the EPA, and Anglo-Dutch with risk-sensitive bidders

[a] The abbreviations of the table are: FPA: first-price auction; SPA: second-price auction; EA: English auction.

Design of the auction and the highlighted element	key lessons	Related literature
EPA with risk-seeking and risk-averse bidders	When bidders are risk-preferring, EPA revenues are much greater than in a risk-averse setting. Rarely do participants follow the equilibrium strategy. The expected revenue of the EPA is lower than that of EA in a risk-averse setting.	[14]
EPA with interdependent values	A "net-premium impact" is crucial to outcomes. When bidders are risk-averse, offering a premium lowers the expected revenue. When bidders are risk-seeking, it raises expected revenues.	[16]
EPA with n-k remaining bidders and affiliated values	The expected revenue of the EPA with n-k remaining is higher than that of EA. When bidders are sufficiently risk-averse, no hybrid format can yield as much as an FPA.	[15]
Anglo-Dutch and standard auctions with risk-aversion and affiliation in bidders' values	When private values are affiliated, any hybrid format that concludes with a first-price stage becomes revenue-dominant over any ascending auction. However, if bidders are risk-averse enough, the FPA makes more money than any other hybrid auction, even the Anglo-Dutch.	[17]
FPA with a resale option	Risk-averse buyers bid more aggressively than risk-neutral ones. With the identical probability distributions, the risk-averse bidder is more likely to be the winner.	[18]
FPA and SPA with multi-dimensional reference-dependent preferences	Low-value bidders underbid, whereas high-value bidders overbid. When bidders are loss-averse in the money dimension, a first-price induced-value auction generates more revenues than a SPA.	[19]
FPA and SPA with endogenous reference points	In the SPA, all bidders will diverge from the value-bidding strategy. In equilibrium, bidders both overbid and underbid relative to the risk-neutral setting.	[20]
FPA with a risk-averse seller and risk-neutral buyers	It may be advantageous for the seller to set a secret reserve price and also fix the auction's rules prior to learning her reserve price.	[21]
FPA and SPA with endogenous reference points and a reserve price	The FPA, with an endogenous reference point and risk-averse buyers, generates higher revenues than the SPA. The opposite relationship can be observed in the case of risk-seeking. The optimal reserve price of the seller is also higher in the FPA.	[22]
Standard auctions with a non-linear probability weighting function	A FPA with a reserve price yields higher revenue than all other standard formats.	[24]
EA versus Vickrey auction	The Vickrey auction strictly outperforms the EA.	[25]
FPA and SPA with buyers and the seller's risk preferences and a reserve price	The optimal reserve price drops as the seller's risk aversion increases, and especially so in FPA. The efficiency of both auctions, especially FPA, is enhanced with greater risk aversion.	[26]
FPA with a varying number of bidders	More competition decreases the reserve price under seller or buyer risk aversion.	[27]
FPA with asymmetrically informed bidders	With risk aversion, a bidder's sensitivity to the information that other bidders have about his private valuation decreases.	[28]

3. Theoretical background

In this section, we present the symmetric equilibrium bid functions for the FPA, SPA, and EPA from Vasserman & Watt (2021), and Brunner, Hu & Oechssler (2014) work [12, 14, and 26]. Through the FPA, SPA and EPA, an indivisible item may be sold to one of $n \geq 2$ potential buyers. The private value of each buyer j of the item, denoted by v_j, is unknown to the other counterparts. Private values, ex ante, are distributed independently on the interval $[C, M]$ by the same distribution function F, whose density function $f = F'$ is strictly positive and continuously differentiable on $[C, M]$.

The aim of each participant is to maximize their expected utility. We assume that all buyers have constant absolute risk aversion (CARA) and follow the same utility function, $u(z)$, with $\emptyset$ parameter. The utility function is

$$u(z) = \frac{e^{\emptyset z} - 1}{\emptyset}, \emptyset \in \mathcal{R}$$

It allows finding a tractable equilibrium solution. It can be negative (risk-loving) or positive (risk-averse).

3.1. FPA equilibrium

The FPA symmetric equilibrium bid functions are

$$B(v) = \frac{1}{\emptyset} . \ln(e^{\emptyset v} - \emptyset \int_0^v \frac{{F_1}^{n-1}(z)}{{F_1}^{n-1}(v)} e^{\emptyset z} dz)$$

Proof. See [26].

3.2. SPA equilibrium

In the SPA, bidding truthfully, irrespective of risk preferences, is a dominant strategy, so the SPA symmetric equilibrium bid functions are

$$B(v) = v$$

Proof. See [12].

3.3. EPA equilibrium

We concentrate on symmetric equilibria when all buyers use the identical B_1 and B_2 bidding strategies for the first and second stages, respectively. The first part will conclude with the $d_3 = B_1(v_3)$, where v_3, represents the third-highest value among all valuations. The seller pays a premium of $\frac{d_2 - d_3}{\alpha}$, for $\alpha \geq 2$ to each finalist in which $d_2 = B_2(v_2)$. The symmetric equilibrium bid function for the EPA is

$$B(v) = -\frac{1}{\emptyset} \ln(\int_v^M e^{-\emptyset z} dH(z|\alpha)), \quad H(z|\alpha) = 1 - (\frac{1 - F}{1 - F}$$

Proof. See [14].

For $\alpha = 2$, when private values are distributed independently on [0,100], equation (5) can be simplified as

$$B(v) = -\frac{1}{\emptyset} \ln(-\frac{2}{\emptyset} \frac{e^{-\emptyset z}(v - 100) - \frac{1}{\emptyset}(e^{-100\emptyset} - e^{-v\emptyset}}{(v - 100)^2}$$

4. Experimental design

In the study, two phases of the experiment were carried out. Part I used a questionnaire created by Holt and Laury (2002) [13] to extract participants' preferences for risk. The auction experiment itself was done in Part II at Iran University of Science and Technology (IUST) and Iran Telecommunication Research Center (ITRC). No monetary incentives were used in the experiments. However, university participants were subject to grade incentives.

Subjects from game theory and decision theory classes of the IUST and selected employees of the ITRC were enlisted to take part in an online survey prior to the auction experiment. All of the 104 subjects in the experiment had master's or PhD degrees. In total, 97 participants completed the online version of the standard Holt-Laury questionnaire ten days before the auction experiment. There are 10 paired lottery choices in the Holt-Laury questionnaire. Option A (a lottery with a different probability of getting 2$ or only 1.6$) and Option B (a lottery with a different probability of getting 3.85$ or only 0.1$). The standard payoffs in the lotteries were multiplied by 100,000 and expressed in "Tomans" so that individuals could grasp the distinctions between the options (Table 2). A subject's interval for their degree of CARA, ∅, can be calculated by observing when they switch from A (less risky) to B (more risky) lottery.

Table 2: Ten lottery choice pairs (payoffs in Toman)

Option A	Option B	Expected Payoff Difference
0.1 of 200,000, 0.9 of 160,000	0.1 of 385,000, 0.9 of 10,000	117,000
0.2 of 200,000, 0.8 of 160,000	0.2 of 385,000, 0.8 of 10,000	83,000
0.3 of 200,000, 0.7 of 160,000	0.3 of 385,000, 0.7 of 10,000	50,000
0.4 of 200,000, 0.6 of 160,000	0.4 of 385,000, 0.6 of 10,000	16,000
0.5 of 200,000, 0.5 of 160,000	0.5 of 385,000, 0.5 of 10,000	-18,000
0.6 of 200,000, 0.4 of 160,000	0.6 of 385,000, 0.4 of 10,000	-51,000
0.7 of 200,000, 0.3 of 160,000	0.7 of 385,000, 0.3 of 10,000	-85,000
0.8 of 200,000, 0.2 of 160,000	0.8 of 385,000, 0.2 of 10,000	-118,000
0.9 of 200,000, 0.1 of 160,000	0.9 of 385,000, 0.1 of 10,000	-152,000
1.0 of 200,000, 0 of 160,000	1.0 of 385,000, 0 of 10,000	-185,000

Even the most risk-averse subjects should switch over to the bottom row in Table 2. Because option B, in the final lottery choices, results in a guaranteed payoff of 385,000 Toman. We excluded those subjects who chose the first option for this lottery or those who switched back from B to A more than once. Therefore, the main experiment was held with 91 participants. The limitation of the number of observations to 48 was due to the difficulty of finding a significant number of risk-seeking subjects. We categorized respondents into risk averse, risk-loving, and risk neutral groups if they selected the safer lottery 5–9, 0-3, and 4 times, respectively.

Ten days after the subjects filled out the questionnaires, the primary experiments at the IUST and ITRC commenced. We categorized subjects into three risk groups depending on their risk tolerance. Each bidding period was attended by eleven groups of four or five participants. There were seven periods in each session. For risk-loving treatments, we drew a value independently (across periods and subjects) from a uniform distribution on [0,100]. These value realizations were used for risk-averse and risk-neutral treatments too. This approach enhances the treatment comparisons. In total, 61% of participants belonged to the risk-averse group, 13% to the risk-loving group, and 26% to the risk-neutral group. The amount of α in the theoretical predictions of the EPA is set at 2.

The HDA consisted of three stages. The reserve price for the first part was announced as the bottom limit of twenty. Considering that the FPA and Dutch auction are strategically equivalent, the first stage was conducted as an FPA. In the initial phase, participants were informed that they were free to participate or not in the first stage. After determining the winner of the first part, those with higher valuations competed in a FPA for the second part. The winner of the Dutch stage did not compete in the second part. After determining the winner of the second stage, the Dutch winner was asked if he would be willing to offer a ten percent over the price of the second-stage winner. The entire winner of the HDA was determined based on his decision, who will either be the winner of the first stage or the winner of the second part.

One day before the beginning of each session, written instructions were emailed to the participants. In addition to verbal instructions, attendees were encouraged to raise any auction-related questions or concerns. Prior to each session, a test period was held to ensure a thorough understanding of the auction procedure, and errors were removed. The auction began once it was verified that all participants had a comprehensive understanding of the auction's rules. Including verbal instruction time, the average duration of an experiment was between 45 and 80 minutes.

5. Experimental results

As a first step, we look at the CRRA coefficient and choice distribution. The subjects implicitly define the variable ∅, which is the CRRA coefficient, when moving between the "safe" and "riskier" lotteries. At the time of the changeover between the two lotteries, the subject asserts that the expected utility of option A ('safe' lotteries) is equivalent to the predicted value of option B ('riskier' lotteries). Once this equality is attained, the 'riskier' option B will have a higher expected utility going forward. These ranges are computed using $u(z) = \frac{1-e^{-\emptyset z}}{\emptyset}$, the CRRA function, in conjunction with the probabilities and payoffs presented in table 2.

The approach we use to define the degree of CARA, ∅, for each participant is as follows. The choices made by each participant on the questionnaire are observed. These decisions are often constant across the entire range of CARA values. Except in cases when the corresponding interval is not specified, we simply utilize the midpoint of these intervals. This is true whether respondents are highly risk-averse (they choose the risky lottery just once) or highly risk-loving (they never opt for the safe lottery). In these two situations, we select the least risk-averse or risk-loving CARA values that still make sense given the participants' decisions. A breakdown of these bounds and their respective classifications is provided in Table 3. For instance, a person who selects option A five times and then switches to option B would be categorized as "slightly risk averse" with an inferred bounds of relative risk aversion of $0.102 < \theta < 0.299$. The first part of the experiment results reveal that a majority of individuals (61%) adhere to risk-averse preferences even without monetary incentives. Only 13% of the subjects are risk-loving.

Table 3. Classifications of risk preference according to lottery choices

Safe options quantity	Relative risk aversion scale for $u(z) = \frac{1-e^{-\emptyset z}}{\emptyset}$	Classification of risk preference	Choices distribution
0-1	$\theta < -0.559$	highly risk loving	0.01
2	$-0.559 < \theta < -0.305$	very risk loving	0.03
3	$-0.305 < \theta < -0.094$	risk loving	0.11
4	$-0.094 < \theta < 0.102$	risk neutral	0.16
5	$0.102 < \theta < 0.299$	slightly risk averse	0.29
6	$0.299 < \theta < 0.516$	risk averse	0.26
7	$0.516 < \theta < 0.784$	very risk averse	0.11
8	$0.516 < \theta < 1.192$	highly risk averse	0.02
9-10	$\theta > 1.192$	stay in bed	0.01

Table 4 presents the mean revenues and standard deviations for the experimental HDA with risk-seeking and risk-averse subjects individually. The experimental results for the EPA and EA from Brunner, Hu & Oechssler's (2014) study [14] are also presented in the table. The theoretical predictions for the EPA and EA are based on the equilibrium bidding functions (3) and (5) as well as the random valuations between 0 and 100 and the CRRA coefficient that subjects revealed in the Holt–Laury task of Brunner, Hu & Oechssler's (2014) study [14]. We used those values to allow comparison of theoretical predictions between the work and their study. Table 4 also contains the theoretical projections for EA and EPA based on experimental valuations assigned to subjects by Brunner, Hu, and Oechssler (2014) [14].

We discover that revenues in the HDA are considerably higher when bidders are risk averse (71.99) than when they are risk-seeking (63.3). On the other hand, the revenues of the HDA are growing at the risk aversion parameter of the buyers. The opposite is true for the premium auction. It suggests that when bidders are risk-averse, a risk-neutral seller would be worse off by paying premiums to the losing buyers in the second stage. The expected revenue of the EA is the same for bidders with different attitudes to the risk. The small number of risk-seeking subjects may be why the risk-averse treatments had less variation than the risk-seeking ones in the HDA. However, the main result is that the HDA generates higher revenues and is more stable (lower standard deviation) than the other two formats. This implies that a seller would prefer the HDA over other formats if bidders are risk-averse.

The difference between the theoretical prediction of this work and experiment and theorical results of Brunner, Hu & Oechssler's (2014) study [14] is due diffrernt to different CRRA coefficient and the fact that our prediction for the EA and EPA is based on random data generation, whereas Brunner, Hu, and Oechssler (2014) [14] used actual realizations for risk-averse and risk-seeking bidders. In fact, the theoretical prediction in the study for the EPA is closer to the reported experimental results of Brunner, Hu & Oechssler's (2014) study [14]. Because of the problem's stochastic nature, we replicated 1000 times each of the set of all the treatment combinations while they had a total of 40 participants in the auction experiment. The difficulty of recruiting sufficient risk-seeking volunteers forced them to limit the number of observations. It can be concluded that the small number of subjects in their experiment may have affected their conclusion that the EPA generates less revenue than they would in a symmetric equilibrium and that participants rarely follow the equilibrium strategy.

Table 4. Mean revenues and standard deviation for the HDA, EPA, and EA

	Revenues	Experiment		Theoretical prediction			
		HDA	EPA[a]	EA	EPA	EA[a]	EPA[a]
Risk averse	Mean	71.9	*60.7*	61.2	69.1	*58.0*	*76.2*
	Standard deviations	10.2	*21.5*	18.8	15.7	*21.5*	*12.9*
Risk seeking	Mean	63.3	*49.8*	61.29	48.3	*58.0*	*55.8*
	Standard deviations	8.25	*21.5*	18.8	9.6	*21.5*	*26.3*

[a] results of Brunner, Hu & Oechssler (2014) study [14]

We will now examine the bidding behavior of subjects considering different values. Fig. 1 shows the bids of subjects for [0,100]. To investigate the details of individual bidding behavior, subjects are divided into low, medium, and high value treatment groups [0,40], (40, 70], and (70, 100], respectively. Recall that because the reserve price is 20, only subjects with a value greater than 20 are eligible to participate in the auction. Figs. 2-4 show offered bids for different value groups. When values are low, there is a modest rise in the frequency of high bids. However, when the values are very close to the reserve price, [20,22], some subjects prefer not to participate in the auction. The individuals in the high valuation groups, (70, 100], behave more conservatively than those in other groups. The difference between values and bids for subjects with low, medium, and high valuations is 2.92, 6.82, and 9.73, respectively. Additionally, the variability of the difference between values and bids also grows with valuation. The standard deviation of these differences for subjects with low, medium, and high valuations is 2.23, 6.91, and 9.68, respectively. The reason for this is that participants with lower valuations believe that winning is nearly impossible, so they place aggressive bids. Examining the subjects' post-victory behavior reveals that they are ecstatic when they win auctions with lower values.

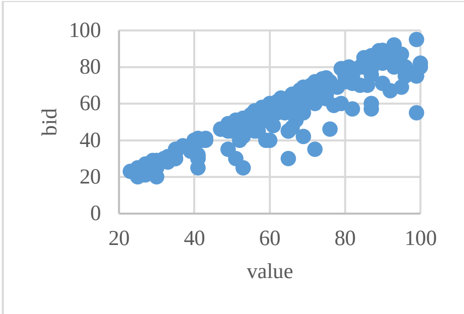

Figure 1: Scatter plot of the bids of subjects depending on their values for [0,100]

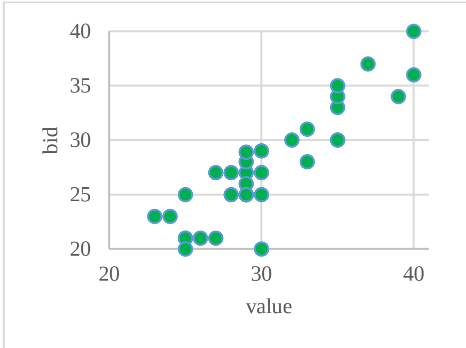

Figure 2: Scatter plot of the bids for subjects with low values: [0,40]
[a] because the reserve price is 20, only subjects with a value greater than 20 are eligible to participate in the auction.

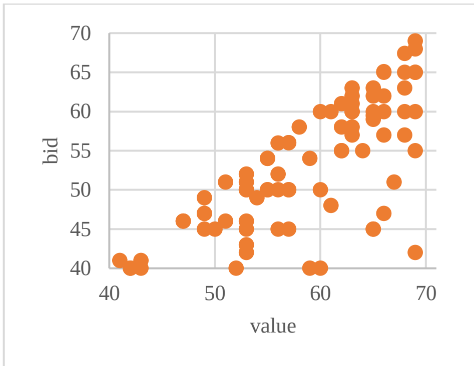

Figure 3: Scatter plot of the bids for subjects with medium values: (40, 70]

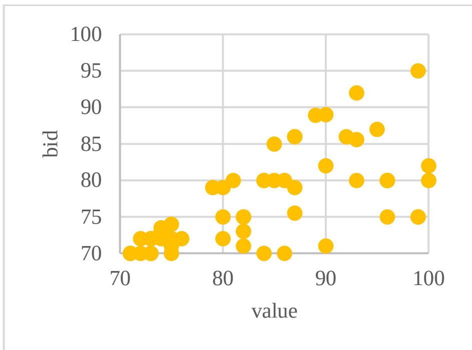

Figure 4: Scatter plot of the bids for subjects with high values: (70, 100]

In table 5, we study the effect of group sizes on the HDA. We find that one more bidder can lead to higher expected revenue and lower variances. Higher competition has a greater impact on the stability of the HDA with risk-seeking and risk-averse bidders than on the expected revenues. One can see that one more bidder makes a 2.09% increase in the expected revenues while making a 21% reduction in the standard deviations.

Table 5: mean revenues and standard deviations for the HDA, EA, and EPA

Revenues	Group size	
	4	5
Mean	71.06	73.15
Standard deviations	11.36	8.93

6. Conclusion

There is an inherent risk in purchasing and selling a property at auction. Bidders are apprehensive about their odds of winning and the amount they should pay, while sellers are uncertain about the likelihood of a successful sale and revenue [12]. Recent experimental investigations have examined standard auctions, the EPA, and the Anglo-Dutch in relation to risk preferences [12, 14, and 15]. The results of these experiments are partially compatible with theory and confirm the common belief that bidders' attitudes to risk are a significant element that influences bidding strategy and, subsequently, the seller's anticipated revenue [14]. But the results show that subjects rarely follow the equilibrium strategy, especially in hybrid formats. This means that in experimental studies, revenues are usually lower than in symmetric equilibrium [12].

In the paper, we considered a classical symmetric and private value setting under the assumption that bidders display CARA. We used an experiment to study the HDA, accounting for different risk preferences for bidders. The HDA consists of the Dutch, sealed bid, and best bid stages. To guarantee that our experiment is more consistent with the model assumption of ex ante symmetric bidders, we separated potential subjects into risk-averse and risk-seeking groups as a novel component of our research. Using the method described by Holt and Laury (2002) [13], this is achieved. The filling in of the questionnaire by subjects took place ten days before the main auction experiment. Then, each group is invited to separate HDA sessions for the main experiment.

We compare results obtained from the experiments of the HDA with the predictions of the EA and the EPA, considering different attitudes to the risk. No monetary incentives were used in the experiments. However, university participants were subject to grade incentives. Our findings indicate that, similar to the FPA, revenues in the HDA grow with risk aversion. Bidders with lower values bid more aggressively than bidders with higher values in both risk-averse and risk-loving treatments. We also discovered that the amount of shading and its variance increase significantly with value. Moreover, greater competition had a greater impact on the stability of the HDA with risk-seeking and risk-averse bidders than on the expected revenues. Finally, the study indicated that a small number of participants may be the reason why some experiments found that auctions generate less revenue than they would in a symmetric equilibrium and that participants rarely follow the equilibrium strategy.

There are some suggested extensions for further research. The bids at different periods of the experiment can also be examined separately. So that it may be monitored how winning and losing in earlier rounds influences the bidding strategy. Due to financial constraints, we were unable to provide any monetary incentives to the participants in this experiment. By providing objective rather than subjective incentives, the behavior of participants with varying degrees of risk tolerance can be examined more precisely.

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